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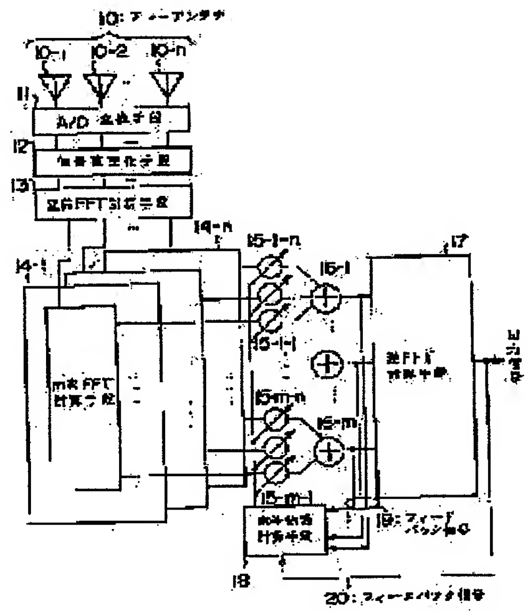
(54) CONTROL METHOD AND DEVICE FOR ARRAY ANTENNA

(57)Abstract:



PROBLEM TO BE SOLVED: To eliminate distortions such as the local drops in the spectra of the entire bands and to finely select a satisfactory beam by reconfiguring the result obtained through multiplication of the signal of every frequency band where the received signal is divided on a frequency axis by a weight coefficient that is adaptively controlled.

SOLUTION: The signals which are received by the antenna elements 10-1 to 10-n form a multibeam by a space FFT calculation means 13. Each beam output of the multibeam is divided into (m) pieces of frequency bands on a frequency axis by each of m-th order FFT calculation means 14-1 to 14-n. These obtained sub-bands (divided frequency bands) are multiplied by a weight coefficient through coefficient multiplication means 15-1-1 to 15-m-n and then added to the sub-bands of the same frequency band with each beam output by addition means 16-1 to 16-m respectively. The obtained (m) pieces of output are inputted to a reverse FFT calculation means 17, and the signals of (m) pieces of time regions are restored by means of (m) pieces of input which are obtained at the some time.

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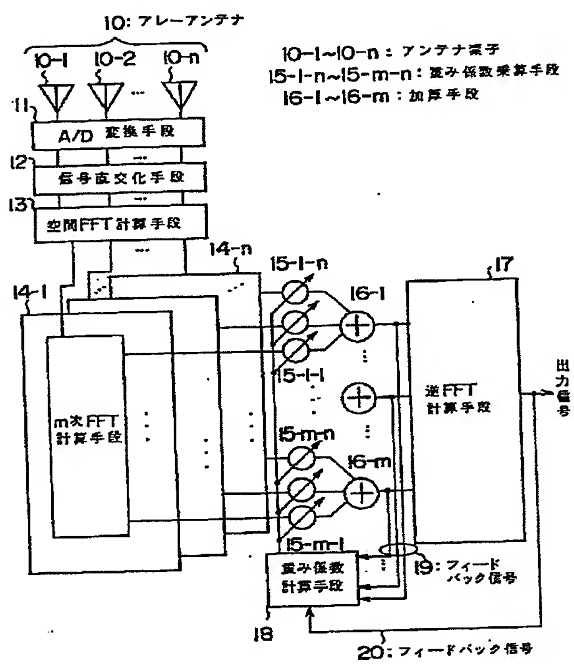
(54)【発明の名称】　アレーアンテナの制御方法及び装置

(57)【要約】
【課題】　本発明は全帯域のスペクトルにおける局所的な落ち込み等の歪をさけ、良好なビームをより細かく選択でき、出力信号のＳ／（Ｎ＋Ｉ）を改善できるるともに重み係数計算の計算量を削減できるアレーアンテナの制御方法及び装置を提供することを目的とする。
【解決手段】　本発明は前記目的を達成するために、電波環境の変化に応じて放射ビームを適応的に形成する適応型アレーアンテナの重み係数を適応的に制御するアレーアンテナの制御方法において、受信信号を周波数軸上で分割し、分割されたそれぞれの周波数帯域の信号に適応的に制御された重み係数を乗算し、乗算したそれぞれの結果を時間軸上の信号に再構成することに特徴がある。



【特許請求の範囲】
【請求項１】　電波環境の変化に応じて放射ビームを適応的に形成する適応型アレーアンテナの重み係数を適応的に制御するアレーアンテナの制御方法において、
受信信号を周波数軸上で分割し、
分割されたそれぞれの周波数帯域の信号に適応的に制御された重み係数を乗算し、
乗算したそれぞれの結果を時間軸上の信号に再構成することを特徴とするアレーアンテナの制御方法。
【請求項２】　電波環境の変化に応じて放射ビームを適応的に形成する適応型アレーアンテナの重み係数を適応的に制御し、ディジタル信号処理を行うアレーアンテナの制御方法において、
各素子アンテナの受信信号に空間ＦＦＴを施して、固定的な直交マルチビームを生成し、
当該各直交マルチビーム出力のすべてを周波数領域に分割し、
分割されたそれぞれの周波数帯域の信号に適応的に制御された重み係数を乗算し、
該乗算結果を周波数帯域毎に合計し、
周波数帯域毎の各合計出力を処理して時間領域の信号に復元することを特徴とするアレーアンテナの制御方法。
【請求項３】　前記各直交マルチビーム出力のすべてに時間領域のＦＦＴを施して周波数領域に分割し、前記重み係数を乗算した乗算結果を周波数帯域毎に合計した各出力を逆ＦＦＴ処理して時間領域の信号に復元する請求項２記載のアレーアンテナの制御方法。
【請求項４】　複数のビーム出力を分割した周波数帯域毎に比較し、所定の基準に照らして所定の数のビームのみを選択する請求項２又は３記載のアレーアンテナの制御方法。
【請求項５】　前記各直交マルチビーム出力のすべてを周波数領域でサブバンドに分割し、分割したサブバンド出力の内、ナイキスト周波数より高い周波数でサンプリングを行ったことによって得られているサブバンド出力及び受信希望信号が帯域制限を受けていることから希望信号成分を含まないサブバンド出力は０として後段に供給せず、希望信号の通過帯域にあたるサブバンドのみを供給し、供給された各サブバンド毎の信号に適応的に制御された重み係数を乗算する請求項２～４のいずれか１項に記載のするアレーアンテナの制御方法。
【請求項６】　複数の素子アンテナからなるアレーアンテナの制御装置において、
各素子アンテナ出力をアナログ信号からディジタル信号に変換するアナログ／ディジタル信号変換手段と、
該アナログ／ディジタル信号変換手段から出力された信号を直交信号に分離する信号直交化手段と、
該信号直交化手段から出力された信号列に空間ＦＦＴを施して直交マルチビームを生成する空間ＦＦＴ計算手段と、
該空間ＦＦＴ計算手段で得られた各ビーム出力を周波数領域でサブバンドに周波数分割を行う帯域分割フィルタと、
適応的に重み係数を計算して重み係数を計算する重み係数計算手段と、
前記空間ＦＦＴ計算手段により選択された所定の数のビーム出力に、前記重み係数計算手段により算出された重み係数を乗算する重み係数乗算手段と、
該重み係数乗算手段により重み係数を乗算された各ビーム出力を、同じサブバンド毎に合計する加算器と、
該加算器により合計された各サブバンド毎の出力を処理して元の帯域に復元する信号再構成フィルタと、
を含むことを特徴とするアレーアンテナの制御装置。
【請求項７】　前記帯域分割フィルタを、空間ＦＦＴ計算手段で得られた各ビーム出力に、時間領域のＦＦＴを施して周波数領域でサブバンドに周波数分割を行うＦＦＴ計算手段とし、また前記信号再構成フィルタを、前記加算器により合計された各サブバンド毎の出力に対して逆ＦＦＴを施す逆ＦＦＴ計算手段とする請求項６に記載のアレーアンテナの制御装置。
【請求項８】　前記空間ＦＦＴ計算手段で分割されたサブバンドのうち、各ビームの同じサブバンド間で所定の基準に照らした比較を行い、所定の基準を満たすビームから所定の数のビームを選択するビーム選択手段を設けた請求項６又は７に記載のアレーアンテナの制御装置。
【請求項９】　分割したサブバンド出力の内、ナイキスト周波数より高い周波数でサンプリングを行ったことによって得られているサブバンド出力及び受信希望信号が帯域制限を受けていることから希望信号成分を含まないサブバンド出力は０として後段に供給せず、希望信号の通過帯域にあたるサブバンドのみを供給する出力制御手段を設けた請求項６～８のいずれか１項に記載のアレーアンテナの制御装置。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、各種無線通信に使用されるアレーアンテナの制御方法及び装置に関するものである。
【０００２】
【従来の技術】適応型アレーアンテナは、各アンテナ素子で受信した信号に、適当な重み係数を掛け合わせて合成することにより、ある方向に強い指向性を持たせたり、逆にある方向から到来する信号に対してのみ、感度を０として受信しなくすることを可能とする。このようなアンテナは、電波環境の変化に応じて適切な重み係数を供給することにより、最適なビーム形成を行って空間フィルタリングを実現し、他の無線通信システムとの干渉を避けるために利用される。
【０００３】近年、ディジタル信号処理技術の発展及び装置の小型化に伴い、ディジタル信号処理を用いたアレ

ーアンテナの移動体通信への適用が注目を集めている。移動体通信システムへの適用を考慮したとき、マルチパスフェージング環境への対応が問題となる。理想的には、希望信号と無相関な干渉信号は空間的にキャンセルする一方、希望信号の遅延信号は取り込んで希望信号に同相合成して、出力信号のＳ／（Ｎ＋Ｉ）を改善に貢献させるべきである。遅延信号の同相合成は、遅延素子（ＴＤＬ;Tapped Delay Line）を用いた時間軸上の信号処理を行う構成と、完全再構成フィルタを用いた周波数軸上の信号処理を行う構成が有効であることが文献で知られている。このような文献には、R. T. Compton, Jr., "The Rela-tionship Between Tapped Delay-Line and FFT Processing in Adaptive Arrays", IEEE Transactions on Antennas and Propagation, vol. 36, No.1, January1988 がある。

【０００４】ここで、図４に同文献による従来のアレーアンテナ制御装置を示すと、各アンテナ素子４１－１～４１－Ｑ（Ｑは正の整数）の出力はそれぞれＡ／Ｄ変換器４２－２～４２－Ｑによって所定のサンプリング周波数でサンプリングされる。アンテナ素子毎に、Ａ／Ｄ変換器４２－２～４２－Ｑによって得られたＫ個のサンプリングは一旦入力バッファ４３－２～４３－Ｑに格納されてＦＦＴ４４－２～４４－Ｑを用いて変換にされ、変換されたアンテナ素子のＫ個の周波数領域サンプルは各々重み係数が乗算される。各アンテナ素子の周波数領域毎における重み係数が乗算されたサンプルは合計されてＩＦＦＴ４５に供給され、時間領域の信号に再構成される。このように、上述した２つの有効な構成の性能に本質的な違いはない。しかし、周波数帯域分割信号処理を行う構成では、分割した帯域に対する重み係数の乗算のような信号処理を並列に行えるために、重み係数の更新周期を長くすることができるので、装置化にあたっては計算機への計算負荷を軽減でき有利となる。

【０００５】周波数帯域分割信号処理を行う従来のアレーアンテナにおいては、受信信号を周波数軸上に分割し、この分割した信号を再構成するフィルタの組み合わせが必要となり、このようなフィルタは完全再構成フィルタと呼ばれている。ＦＦＴ／ＩＦＦＴの組み合わせは、完全再構成フィルタの一つである。ディジタル信号処理を行う際には、計算負荷の問題からも、ＦＦＴ／ＩＦＦＴの組み合わせによる完全再構成フィルタを採用するのが有効である。

【０００６】一方、装置化を考慮すると、重み係数計算アルゴリズムへの計算機への計算負荷の軽減は、重要な問題となる。重み係数を得るための計算負荷の軽減手法として、従来、重み係数計算アルゴリズムの前段で、予め固定的なマルチビームを構成し、各ビーム出力に信号処理を行うビームスペース方式がある。このビームスペース方式は、アレーアンテナのビーム形成のための信号処理を行うに当たって、素子出力を直接用いるのではなく、前処理として予め固定的なマルチビームを形成し、ビームの出力に対して信号処理を行う手法である。このような固定的なマルチビームは、アナログ領域ではバトラーマトリックス、ディジタル領域では空間ＦＦＴにより形成されるのが一般的である。ビームスペース方式を適用して、形成された固定的なビームの出力を利用することにより、空間分割を行っているので、希望信号電力は特定のビームに集中することになり、Ｓ／Ｎ比を改善した受信信号が得られるメリットがある。

【０００７】

【発明が解決しようとする課題】このようなメリットを持つ帯域分割型アレーアンテナであるが、移動体通信システムへの適用を考えたとき、その環境の特徴として、マルチパスフェージング環境により生じた希望信号の遅延信号が多数存在し、その数はアレーアンテナの自由度を通常越えていることがあげられる。このような環境は、アンテナが最適受信を行える重み係数をなんらかの方法により探索する途中において、最適解でなく、局所的な解に陥り易くする。結果として、アレーアンテナの性能を劣化させることになる。

【０００８】また、実際の装置化を考慮した場合、周波数分割型アレーアンテナは、信号処理に要する重み係数の数がアレーの素子数及び帯域分割を行うＦＦＴの次数に比例して増大するので、重み係数計算アルゴリズムの次数が大きくなり、計算量が膨大となる。希望信号の遅延信号を取り込んで、希望信号に同相合成させる能力は、ＴＤＬを用いた時間領域信号処理を行う構成ではＴＤＬの長さ、ＦＦＴ／ＩＦＦＴを用いる周波数帯域分割信号処理を行う構成ではＦＦＴの次数、すなわち帯域分割の数が直接のパラメータとなり、双方ともそれが長い程取り込みを行える遅延量が大きくなることが知られている。しかし、両方式とも、遅延信号を取り込む能力を追及するほど、計算するべき重み係数の数が増えることになり、これはたとえば入力信号の３乗に計算量が増大するＲＬＳ(Recursive Least Squa-re) 法のようなアルゴリズムを重み係数計算アルゴリズムとして採用する場合は影響が大きい。

【０００９】一方、前述のビームスペース方式の適用により、特定のビームに希望信号電力を集中させることができれば、逆に希望信号電力がほとんどないビーム出力も得られることになる。そこで、従来から固定的マルチビームを形成した後、その各出力を所定の基準で比較し、良好なもののみを選択してビーム数を削減する手法がある。しかし、このような構成では、電力やＳ／Ｎを比較するにあたって全周波数帯域を対象としているため、マルチパスフェージング環境で特に広帯域通信において生じ易いとされる周波数軸上でのスペクトルの歪を含んだままでビームの選択をすることになる。このため、全帯域のスペクトルの一部が選択的に低くなっている場合、この歪はそのまま残留することになるので、時

間領域において波形に歪が残る。
【0010】本発明はこれらの問題点を解決するためのもので、ビームスペース方式を採用し、かつ完全再構成フィルタの構成をなすことにより、全帯域のスペクトルにおける局所的な落ち込み等の歪をさけ、良好なビームをより細かく選択でき、出力信号のS／（N＋I）を改善できると共に、オーバーサンプリング分だけの情報信号成分を含まないサブバンドの出力は採用しないこととすることにより、遅延信号取り込み能力を落とすことなく、計算量を削減できるアレーアンテナの制御方法及び装置を提供することを目的とする。
【0011】
【課題を解決するための手段】以上のような問題点を解決するために、本発明はビームスペース方式を帯域分割型アレーアンテナに適用する。前述のように、ビームスペース方式は、アレーアンテナのビーム形成のための信号処理を行うに当たって、素子出力を直接用いるのではなく、前処理として予め固定的なマルチビームを形成し、ビームの出力に対して信号処理を行う手法であり、S／N比を改善した受信信号が得られるメリットがある。このため、何らかの重み係数計算アルゴリズムが最適受信を行う重み係数の探索を行うに当たって局所的な解に落ち着くことなく、より最適に近い重み係数の組み合わせを求めやすくなる。
【0012】一方、計算量軽減のための手法としての従来のビームスペース方式の構成におけるビーム選択法は、選択する指標はなんであれ、選択の対象が当該受信信号の全帯域のスペクトルが対象となっていた。このため、周波数選択性フェージング環境において生じるスペクトルの歪の影響を受けることになる。
【0013】この問題点を解決するための手段として、電波環境の変化に応じて放射ビームを適応的に形成する適応型アレーアンテナの重み係数を適応的に制御するアレーアンテナの制御方法において、受信信号を周波数軸上で分割し、分割されたそれぞれの周波数帯域の信号に適応的に制御された重み係数を乗算し、乗算したそれぞれの結果を時間軸上の信号に再構成する。また、ディジタル信号処理を行うアレーアンテナの制御方法においては、各素子アンテナの受信信号に空間ＦＦＴを施して、固定的な直交マルチビームを生成し、当該各直交マルチビーム出力のすべてを周波数領域に分割し、分割されたそれぞれの周波数帯域の信号に適応的に制御された重み係数を乗算し、該乗算結果を周波数帯域毎に合計し、周波数帯域毎の各合計出力を処理して時間領域の信号に復元する。よって、本発明によれば、全帯域のスペクトルにおける局所的な落ち込み等の歪をさけ、良好なビームをより細かく選択できる。
【0014】また、各直交マルチビーム出力のすべてに時間領域のＦＦＴを施して周波数領域に分割し、重み係数を乗算した乗算結果を周波数帯域毎に合計した各出力を逆ＦＦＴ処理して時間領域の信号に復元する。更に、複数のビーム出力を分割した周波数帯域毎に比較し、所定の基準に照らして所定の数のビームのみを選択する。このため、全帯域のスペクトルにおける局所的な落ち込み等の歪をさけ、良好なビームをより細かく選択できる。結果として、出力信号のS／（N＋I）を改善できる。
【0015】更に、ディジタル信号処理を施すにあたって、受信信号がアナログ／ディジタル信号変換を受けるとき、その際のサンプリング周波数はナイキスト周波数より高く設定されるのが普通である。この状態を周波数軸上で見れば、オーバーサンプリング分だけの情報信号成分を含まないサブバンドが生成されていることになる。情報信号を本来含まないサブバンドでは、その成分のほとんどは雑音であり、重み係数を与えて乗算する必要はない。しかし、遅延信号の取り込みには貢献していることになる。よって、各直交マルチビーム出力のすべてを周波数領域でサブバンドに分割し、分割したサブバンド出力の内、ナイキスト周波数より高い周波数でサンプリングを行ったことによって得られているサブバンド出力及び受信希望信号が帯域制限を受けていることから希望信号成分を含まないサブバンド出力は０として後段に供給せず、希望信号の通過帯域にあたるサブバンドのみを供給し、供給された各サブバンド毎の信号に適応的に制御された重み係数を乗算する。結果として、オーバーサンプリングにより生じているサブバンドの出力は採用しないこととすることで、遅延信号取り込み能力を落とすことなく、計算量を削減できる。なお、このような計算量削減の方法は、時間領域の信号処理を行うＴＤＬを用いた構成では不可能である。
【0016】
【発明の実施の形態】以下、本発明の実施の形態例を図面により説明する。図１は、本発明の第１の実施の形態例のアレーアンテナの制御装置の構成を示すブロック図である。同図の装置は、複数のアンテナ素子１０－１～１０－ｎ（ｎは正の整数）からなるアレーアンテナ１０、およびこれを制御するための制御装置である。なお、本発明によるアレーアンテナの制御装置は、２次元アレーアンテナにも適用可能であるが、以下に示す実施形態例において説明を簡単にするため、１次元アレーアンテナ（等間隔線形アレーアンテナ）へ適用した場合を示すこととする。同図において、１１はアンテナ素子１０－１～１０－ｎからのアナログ出力をディジタル信号に変換するアナログ／ディジタル信号変換手段（以下、Ａ／Ｄ変換手段と称す）、１２はＡ／Ｄ変換手段１１の出力をＩ／Ｑ直交チャネルに分離して各直交信号を生成する信号直交化手段、１３は信号直交化手段１２の各出力から直交マルチビーム出力を生成する空間ＦＦＴ計算手段、１４－１～１４－ｎは空間ＦＦＴ計算手段１３の各出力をそれぞれｍ個（ｍは正の整数）割するｍ次ＦＦ

T計算手段、１５－１－１～１５－ｍ－ｎはm次ＦＦＴ計算手段１４－１～１４－ｎの各々から得られたサブバンド毎出力に後述する重み係数計算手段１８により計算された重み係数を乗算する重み係数乗算手段、１６－１～１６－ｍは各ビーム出力の内で同じ周波数帯域のサブバンドを加算する加算手段、１７は同時に得られたｍ個の入力を用いてｍ個の時間領域の信号に復元する逆ＦＦT計算手段、１８は後述するフィードバック信号１９又は２０を入力子として、あるいは適応的に重み係数を算出する重み係数計算手段である。

【００１７】次に、本発明の第１の実施の形態例におけるアレーアンテナの制御装置の動作について図１に基づいて説明する。各アンテナ素子１０－１～１０－ｎで受信された信号は、Ａ／Ｄ変換手段１１により所定のサンプリング周波数でディジタル信号に変換され、信号直交化手段１２でＩ／Ｑ直交チャネルに分離されたあと、空間ＦＦＴ計算手段１３によりマルチビームを形成する。形成された各ビームの出力は、それぞれm次ＦＦＴ計算手段１４－１～１４－ｎにより周波数字軸上でｍ個の周波数帯域に分割される。ここで、分割された周波数帯域をサブバンドと呼ぶ。ｎ個のビーム出力のそれぞれがｍ個のサブバンドに分割されるため、結果としてｎｍ個のサブバンド出力が得られることになる。

【００１８】そして、得られたサブバンドはそれぞれ重み係数乗算手段１５－１－１～１５－ｍ－ｎにより重み係数を乗算された後、加算手段１６－１～１６－mにより各ビーム出力で同じ周波数帯域のサブバンドを加算する。得られたｍ個の出力は、逆ＦＦＴ計算手段１７に入力され、同時に得られるｍ個の入力を用いてｍ個の時間領域の信号を復元する。

【００１９】一方、重み係数計算手段１８は、フィードバック信号１９又は２０のいずれかを入力として所定のアルゴリズムにより重み係数を算出し、前出の重み係数乗算手段１５－１－１～１５－ｍ－ｎに供給する。フィードバック信号１９は前出の加算手段１６－１～１６－ｍを取り込んだ信号であり、フィードバック信号２０は、逆ＦＦＴ計算手段１７の出力である。

【００２０】図２は、本発明の第２の実施の形態例のアレーアンテナの制御装置の構成を示すブロック図である。同図において、図１のアレーアンテナの制御装置と同じ構成要件は同じ参照符号を付与する。異なる構成要件として、２１－１～２１－ｍはm次ＦＦＴ計算手段１４－１～１４－ｎからの各ビーム間の同じ周波数帯域のサブバンド毎に設けられ、入力されたｎ個のサブバンドを所定の基準にしたがってその特性を比較し、良好なものからｐ（ｐは正の整数、ｐ≦ｎ）個のビーム出力を選択するビーム選択手段である。

【００２１】次に、本発明の第２の実施の形態例におけるアレーアンテナの制御装置の動作について図２に基づいて説明する。アンテナ素子１０－１～１０－ｎで受信された信号は、Ａ／Ｄ変換手段１１により所定のサンプリング周波数でディジタル信号に変換され、信号直交化手段１２でＩ／Ｑ直交チャネルに分離されたあと、空間ＦＦＴ計算手段１３によりマルチビームを形成する。形成された各ビームの出力は、それぞれm次ＦＦＴ計算手段１４－１～１４－ｎにより周波数字軸上でｍ個の帯域に分割される。ここで、分割された帯域をサブバンドと呼ぶ。

【００２２】次に、得られたサブバンド出力は、各ビーム間の同じ帯域のサブバンド毎にビーム選択手段２１－１～２１－ｍに入力される。ここでは、入力されたｎ個のサブバンドを所定の基準にしたがってその特性を比較し、良好なものからｐ個のビーム出力を選択して出力する。選択されたｐ個のビーム出力のそれぞれがｍ個のサブバンドに分割されるため、結果としてｐｍ個のサブバンド出力が得られることになる。

【００２３】そして、得られたサブバンドはそれぞれ重み係数乗算手段１５－１－１～１５－ｍ－ｐより重み係数を乗算された後、加算手段１６－１～１６－ｍにより各ビーム出力で同じ周波数帯域のサブバンドを加算する。得られたｍ個の出力は、逆ＦＦＴ計算手段１７に入力され、同時に得られるｍ個の入力を用いてｍ個の時間領域の信号を復元する。なお、重み係数計算手段１８については第１の実施の形態例において前述したことと同様である。

【００２４】図３は、本発明の第３の実施の形態例のアレーアンテナの制御装置の構成を示すブロック図である。同図において、図１のアレーアンテナの制御装置と同じ構成要件は同じ参照符号を付与する。異なる構成要件として、m次ＦＦＴ計算手段１４－１～１４－ｎにおいて、Ａ／Ｄ変換に当たってオーバーサンプリングしていることによって得られているもの、また、受信後の帯域制限により信号成分がなくなっているサブバンドは後段に供給しない点であり、図中では０と表記している。

【００２５】次に、本発明の第３の実施の形態例におけるアレーアンテナの制御装置の動作について図３に基づいて説明する。アンテナ素子１０－１～１０－ｎで受信された信号は、Ａ／Ｄ変換手段１１により所定のサンプリング周波数でディジタル信号に変換される。次に、信号直交化手段１２でＩ／Ｑ直交チャネルに分離されたあと、空間ＦＦＴ計算手段１３によりマルチビームを形成する。形成された各ビームの出力は、それぞれm次ＦＦT計算手段１４－１～１４－ｎにより周波数字軸上でｍ個の帯域に分割される。ここで、分割された帯域をサブバンドと呼ぶ。ｎ個のビーム出力のそれぞれがｍ個のサブバンドに分割されるため、結果としてｎｍ個のサブバンド出力が得られることになる。

【００２６】そして、得られたサブバンドのうち、Ａ／Ｄ変換に当たってオーバーサンプリングしていることによって得られているもの、つまりナイキスト周波数より

高い周波数でサンプリングを行ったことによって得れるもの、また受信後の帯域制限により信号成分がなくなっているサブバンドは、後段に供給しない。こうして得られた信号成分が存在するサブバンドはそれぞれ重み係数乗算手段１５－１－１～１５－ｍ－ｎにより重み係数を乗算された後、加算手段１６－１～１６－ｍにより各ビーム出力で同じ帯域のサブバンドを加算する。得られたｍ個の出力は、逆ＦＦＴ計算手段１７に入力され、同時に得られるｍ個の入力を用いてｍ個の時間領域の信号を復元する。なお、重み係数計算手段１８については第１の実施の形態例において前述したことと同様である。

【００２７】なお、上述した各実施の形態例の構成は単なる一例であり、各実施の形態例の組み合わせも可能であり、その組み合わせも任意に構成できるものである。また、以上述べた実施の形態例は本発明の一例を示すものであって限定するものではなく、本発明は他の変形なる態様及び変更なる態様で実施することができるものである。よって、本発明の範囲は特許請求の範囲及びその均等範囲によってのみ規定されるものである。

【００２８】

【発明の効果】以上詳細に説明したように、本発明によれば、ビームスペース方式を採用し、かつ完全再構成フィルタの構成をなすことにより、全帯域のスペクトルにおける局所的な落ち込み等の歪をさけ、良好なビームをより細かく選択でき、結果として、出力信号のＳ／（Ｎ＊＋Ｉ）を改善できる。また、オーバーサンプリング分だけの情報信号成分を含まないサブバンドの出力は採用しないこととすることにより、遅延信号取り込み能力を落とすことなく、計算量を削減できる。

【図面の簡単な説明】

【図１】本発明の第１の実施の形態例のアレーアンテナの制御装置の構成を示すブロック図である。

【図２】本発明の第２の実施の形態例のアレーアンテナの制御装置の構成を示すブロック図である。

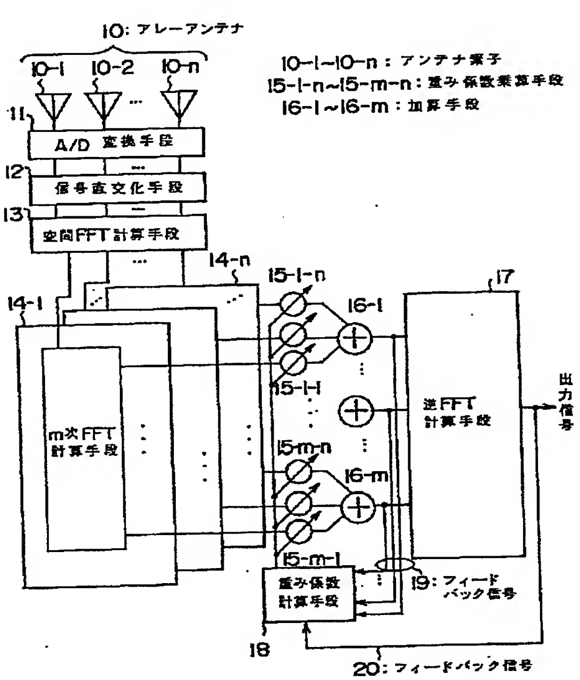
【図３】本発明の第３の実施の形態例のアレーアンテナの制御装置の構成を示すブロック図である。

【図４】従来のアレーアンテナ制御装置の構成を示すブロック図である。

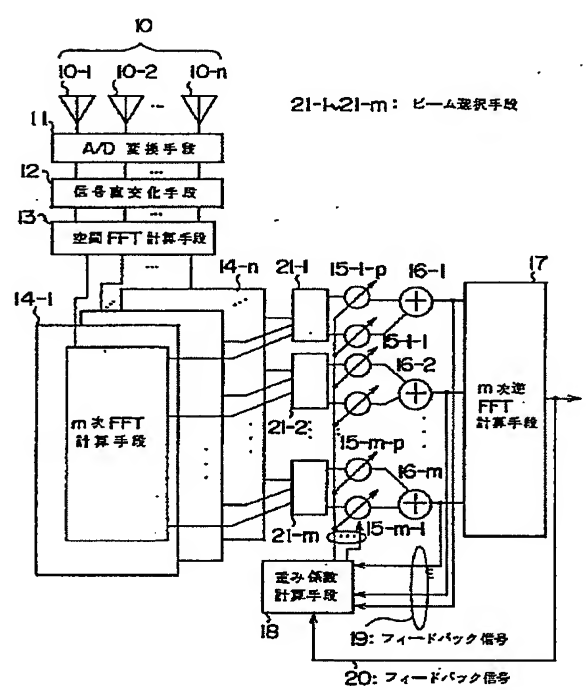
【符号の説明】

１０　アレーアンテナ
１０－１～１０－ｎ　アンテナ素子
１１　アナログ／ディジタル変換手段
１２　信号直交化手段
１３　空間ＦＦＴ計算手段
１４－１～１４－ｎ　ｍ次ＦＦＴ計算手段
１５－１－１～１５－ｍ－ｎ　重み係数乗算手段
１６－１～１６－ｍ　加算手段
１７　逆ＦＦＴ計算手段
１８　重み係数計算手段
２１－１～２１－ｍ　ビーム選択手段

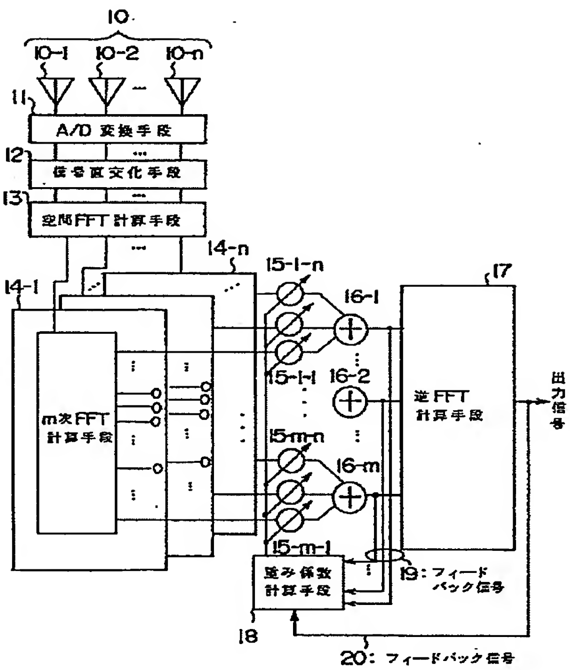
【図１】



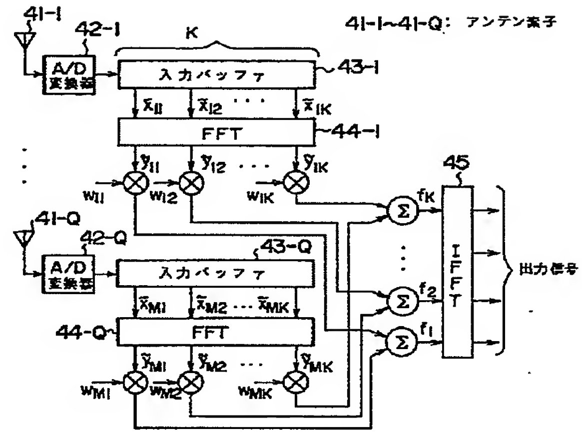
【図２】



【図３】


10
10-1
10-2
10-n
11
A/D 変換手段
12
信号直交化手段
13
空間FFT計算手段
14-1
14-n
m次FFT計算手段
15-1-n
15-1-1
15-m-n
15-m-1
16-1
16-2
16-m
17
逆FFT計算手段
出力信号
重み係数計算手段
18
19：フィードバック信号
20：フィードバック信号

【図４】


41-1
42-1
K
41-1~41-Q：アンテナ素子
A/D 変換器
入力バッファ
43-1
FFT
44-1
45
41-Q
42-Q
43-Q
44-Q
IFFT
出力信号

(6)

JAPANESE [JP,11-234025,A]

CLAIMS DETAILED DESCRIPTION TECHNICAL FIELD PRIOR ART EFFECT OF THE INVENTION TECHNICAL PROBLEM MEANS DESCRIPTION OF DRAWINGS DRAWINGS

[Translation done.]

CLAIMS

[Claim(s)]
[Claim 1] The control approach of the array antenna which divides an input signal on a frequency shaft, carries out the multiplication of the weighting factor controlled by the signal of each divided frequency band accommodative, and is characterized by to reconfigurate each result which carried out multiplication to the signal on a time-axis in the control approach of the array antenna which controls the weighting factor of the ecad array antenna which forms a radiation beam accommodative according to change of an electric-wave environment accommodative.
[Claim 2] In the control approach of an array antenna of controlling the weighting factor of the ecad array antenna which forms a radiation beam accommodative according to change of an electric-wave environment accommodative, and performing digital signal processing Give space FFT to the input signal of each component antenna, and a fixed rectangular cross multi-beam is generated. The multiplication of the weighting factor which divided each rectangular cross multi-beam power of all concerned into the frequency domain, and was controlled by the signal of each divided frequency band accommodative is carried out. The control approach of the array antenna characterized by totaling this multiplication result for every frequency band, processing each total output for every frequency band, and restoring to the signal of a time domain.
[Claim 3] The control approach of the array antenna according to claim 2 which gives FFT of a time domain to said each rectangular cross multi-beam power of all, divides into a frequency domain, carries out reverse FFT processing of each output which totaled the multiplication result of having carried out the multiplication of said weighting factor, for every frequency band, and is restored to the signal of a time domain.
[Claim 4] The control approach of the array antenna according to claim 2 or 3 which compares for every frequency band and chooses only a predetermined number of beams in the light of predetermined criteria of having divided two or more beam power.
[Claim 5] Said each rectangular cross multi-beam power of all is divided into a subband in a frequency domain. The subband output which does not contain the signal component of choice since the subband output and the signal wishing reception which are acquired by having sampled on the frequency higher than a Nyquist rate among the divided subband outputs have received the band limit is not supplied to the latter part as 0. The control approach of the array antenna which a publication makes any 1 term of claims 2-4 which carry out the multiplication of the weighting factor which supplied only the subband which hits the passband of the signal of choice, and was controlled accommodative by the signal for every supplied subband.
[Claim 6] The analog / a digital signal conversion means to change each component antenna output into a digital signal from an analog signal in the control device of the array antenna which consists of two or more component antennas, A signal orthogonalization means to divide into a rectangular signal the signal outputted from this analog / digital signal conversion means, A space FFT count means to give space FFT to the signal train outputted from this signal orthogonalization means, and to generate a rectangular cross multi-beam, The band division filter which performs a frequency division for each beam power obtained with this space FFT count means in a subband in a frequency domain, A weighting-factor count means to calculate a weighting factor by calculating a weighting factor accommodative, The weighting-factor

multiplication means which carries out the multiplication of the weighting factor computed by said weighting-factor count means to a predetermined number of beam power chosen by said space FFT count means, The control unit of the array antenna characterized by including the adder which totals each beam power by which multiplication was carried out in the weighting factor with this weighting-factor multiplication means for every same subband, and the signal reconstruction filter which processes the output for every subband totaled by this adder, and is restored to the original band.
[Claim 7] The control unit of the array antenna according to claim 6 made into a reverse FFT count means to perform Reverse FFT to the output for every subband which considered as an FFT count means to give FFT of a time domain to each beam power obtained with the space FFT count means in said band division filter, and to carry out a frequency division to it in a frequency domain at a subband, and was totaled by said adder in said signal reconstruction filter.

[Claim 8] The control unit of the array antenna according to claim 6 or 7 which established a beam selection means to choose a predetermined number of beams from the beam which performs the comparison compared with the criteria of predetermined between the subbands with each beam same among the subbands divided with said space FFT count means, and meets the predetermined criteria.
[Claim 9] The subband output which does not contain the signal component of choice since the subband output and the signal wishing reception which are acquired by having sampled on the frequency higher than a Nyquist rate among the divided subband outputs have received a band limit is the control unit of an array antenna given in any 1 term of claims 6-8 which established an output-control means does not supply the latter part as 0 but supply only the subband which hits the passband of the signal of choice.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the control approach of an array antenna and equipment which are used for various radiocommunication.
[0002]
[Description of the Prior Art] An ecad array antenna gives directivity strong against a certain direction by multiplying and compounding a suitable weighting factor to the signal received by each antenna element, or makes it possible not to receive as 0 and to carry out sensibility only to the signal which comes from the direction in reverse. By supplying a suitable weighting factor according to change of an electric-wave environment, such an antenna performs the optimal beam shape **, realizes spatial filtering, and it is used in order to avoid interference with other radio communications systems.
[0003] In recent years, application to the mobile communications of the array antenna using digital signal processing attracts attention with development of a digital-signal-processing technique and the miniaturization of equipment. When application to mobile communication system is taken into consideration, the response to a multi-pass phasing environment poses a problem. While canceling spatially an interference signal [**** / signal / of choice /-less], the delay signal of the signal of choice should be incorporated, should carry out in-phase synthesis to the signal of choice, and should make S/(N+I) of an output signal contribute to an improvement ideally. It is known for reference that the in-phase synthesis of a delay signal has effective configuration which performs signal processing on the time-axis which used the delay element (TDL;Tapped Delay Line) and configuration which performs signal processing on the frequency shaft using a full reconstruction filter. In such reference, they are R.T.Compton, Jr., "The Rela-tionship Between Tapped Delay-Line and FFT Processing in Adaptive Arrays", IEEE Transactions on Antennas and Propagation, vol.36, No.1, and January1988. It is.
[0004] If here shows the conventional array antenna control unit by this reference to drawing 4 , the output of each antenna element 41-1 - 41-Q (Q is a forward integer) will be sampled by A/D converter 42-2 - 42-Q with a predetermined sampling frequency, respectively. For every antenna element, K samplings obtained by A/D converter 42-2 - 42-Q are once stored in an input buffer 43-2 - 43-Q, and are carried out to conversion using FFT 44-2 - 44-Q, and, as for K frequency-domain samples of the changed antenna element, the multiplication of the weighting factor is carried out respectively. The sample to which the multiplication of the weighting factor in every frequency domain of each antenna element was carried out is totaled, is supplied to IFFT45, and is reconfigurated by the signal of a time domain. Thus, there is no difference essential to the engine performance of two effective configurations mentioned above. However, with the configuration which performs frequency band division signal processing, since signal processing like the multiplication of a weighting factor to the divided band can be performed to juxtaposition and the updating period of a weighting factor can be lengthened, the count load to a computer can be mitigated in instrumentation, and it becomes advantageous.
[0005] In the conventional array antenna which performs frequency band division signal processing, an input signal is divided on a frequency shaft, the combination of the filter which

reconfigurates this divided signal is needed, and such a filter is called the full reconstruction filter. The combination of FFT/IFFT is one of the full reconstruction filters. In case digital signal processing is performed, it is effective to adopt the full reconstruction filter by the combination of FFT/IFFT also from the problem of a count load.
[0006] On the other hand, if instrumentation is taken into consideration, relief of the count load to the computer to a weighting-factor computational algorithm will pose an important problem. As the relief technique of the count load for obtaining a weighting factor, conventionally, a fixed multi-beam is beforehand constituted from the preceding paragraph of a weighting-factor computational algorithm, and there is a beam space method which carries out signal processing to each beam power. In performing signal processing for beam shape ** of an array antenna, this beam space method is the technique of forming a beforehand fixed multi-beam as pretreatment not using a component output, and performing signal processing to the output of a beam directly. As for such a fixed multi-beam, it is common to be formed of Space FFT in the Butler matrix and a digital field in an analog field. Since space division is performed by applying a beam space method and using the output of the formed fixed beam, it will concentrate on a specific beam and the signal power of choice has the merit from which the input signal which has improved the S/N ratio is obtained.
[0007]
[Problem(s) to be Solved by the Invention] Although it is a band assembled-die array antenna with such a merit, when application to mobile communication system is considered, many delay signals of the signal of choice produced according to the multi-pass phasing environment exist as a description of the environment, and it is raised that the number is usually over the degree of freedom of an array antenna. Such an environment makes it easy to lapse into the local solution instead of an optimum solution, as an antenna searches for the weighting factor which can perform the optimal reception by a certain approach. The engine performance of an array antenna is made to deteriorate as a result.
[0008] Moreover, when actual instrumentation is taken into consideration, since the number of the weighting factors which signal processing takes increases in proportion to the degree of FFT which performs the element number of an array, and band division, the degree of a weighting-factor computational algorithm becomes large, and a frequency-division mold array antenna becomes huge [computational complexity]. It is known that the capacity which incorporates the delay signal of the signal of choice and carries out in-phase synthesis to the signal of choice serves as a direct, the degree of FFT, i.e., number of band division, parameter with the configuration which performs time-domain signal processing which used TDL in the configuration which performs frequency band division signal processing which uses the die length of TDL and FFT/IFFT, and the amount of delay in which both sides are in confusion, so that it is long will become large. However, this is RLS (Recursive Least Squa-re) to which the number of both methods of the weighting factors which should be calculated, so that the capacity to incorporate a delay signal is investigated will increase, and computational complexity increases to the cube of an input signal. Effect is large when adopting an algorithm like law as a weighting-factor computational algorithm.
[0009] On the other hand, if the signal power of choice can be centralized on a specific beam by application of the above-mentioned beam space method, the beam power which does not almost have the signal power of choice in reverse will also be obtained. Then, after forming a fixed multi-beam from the former, predetermined criteria compare each of that output and there is the technique of choosing only a good thing and reducing the number of beams. However, with such a configuration, since it is aimed at the perimeter wave number band in comparing power and S/N, a beam will be chosen, with the distortion of the spectrum on the frequency shaft it is supposed that is easy to be generated especially in broadband communication in a multi-pass phasing environment included. For this reason, since this distortion will remain as it is when some spectrums of all bands are low selectively, in a time domain, distortion remains in a wave.
[0010] By this invention's being for solving these troubles, and adopting a beam space method, and constituting a full reconstruction filter While being able to avoid distortion of the local depression in the spectrum of all bands etc., being able to choose a good beam more finely and

being able to improve S/(N+I) of an output signal The output of the subband which does not contain the information signal component only for over sampling technique aims at offering the control approach of an array antenna and equipment which can reduce computational complexity, without dropping delay signal incorporation capacity by supposing that it does not adopt.
[0011]
[Means for Solving the Problem] In order to solve the above troubles, this invention applies a beam space method to a band assembled-die array antenna. As mentioned above, in performing signal processing for beam shape ** of an array antenna, directly, a beam space method forms a beforehand fixed multi-beam as pretreatment not using a component output, is the technique of performing signal processing to the output of a beam, and has the merit from which the input signal which has improved the S/N ratio is obtained. For this reason, when a certain weighting-factor computational algorithm searches for the weighting factor which performs the optimal reception, it falls and wears in a local solution and there is nothing with Lycium chinense, and it becomes easy to search for the combination of a near weighting factor the more nearly optimal.
[0012] On the other hand, as for the index which chooses the beam choice method in the configuration of the conventional beam space method as technique for computational complexity relief, the spectrum of all the bands of the input signal concerned had been [the object of that and selection] applicable why. For this reason, it will be influenced [distorted] of the spectrum produced in a frequency selective phasing environment.
[0013] In the control approach of the array antenna which controls the weighting factor of the ecad array antenna which forms a radiation beam accommodative as a means for solving this trouble according to change of an electric-wave environment accommodative, the multiplication of the weighting factor which divided the input signal on the frequency shaft and was controlled by the signal of each divided frequency band accommodative is carried out, and each result which carried out multiplication is reconfigurated to the signal on a time-axis. Moreover, in the control approach of an array antenna of performing digital signal processing, space FFT is given to the input signal of each component antenna, a fixed rectangular cross multi-beam is generated, the multiplication of the weighting factor which divided each rectangular cross multi-beam power of all concerned into the frequency domain, and was controlled by the signal of each divided frequency band accommodative is carried out, this multiplication result is totaled for every frequency band, each total output for every frequency band is processed, and it restores to the signal of a time domain. Therefore, according to this invention, distortion of the local depression in the spectrum of all bands etc. is avoided, and a good beam can be chosen more finely.
[0014] Moreover, FFT of a time domain is given to each rectangular cross multi-beam power of all, it divides into a frequency domain, reverse FFT processing of each output which totaled the multiplication result of having carried out the multiplication of the weighting factor, for every frequency band is carried out, and it restores to the signal of a time domain. Furthermore, it compares for every frequency band which divided two or more beam power, and only a predetermined number of beams are chosen in the light of predetermined criteria. For this reason, distortion of the local depression in the spectrum of all bands etc. is avoided, and a good beam can be chosen more finely. As a result, S/(N+I) of an output signal is improvable.
[0015] Furthermore, when an input signal receives an analog / digital signal conversion in performing digital signal processing, as for the sampling frequency in that case, it is common to be set up more highly than a Nyquist rate. If this condition is seen on a frequency shaft, the subband which does not contain the information signal component only for over sampling technique will be generated. In the subband which originally does not include an information signal, most of the components are noises, and it does not have to give and carry out the multiplication of the weighting factor. However, it will contribute to incorporation of a delay signal. Therefore, each rectangular cross multi-beam power of all is divided into a subband in a frequency domain. The subband output which does not contain the signal component of choice since the subband output and the signal wishing reception which are acquired by having sampled on the frequency higher than a Nyquist rate among the divided subband outputs have received the band limit is not supplied to the latter part as 0. The multiplication of the weighting factor

which supplied only the subband which hits the passband of the signal of choice, and was controlled accommodative by the signal for every supplied subband is carried out. As a result, the output of the subband produced by over sampling technique is supposing that it does not adopt, and it can reduce computational complexity, without dropping delay signal incorporation capacity. In addition, the approach of such a computational complexity cutback is impossible with the configuration using TDL which performs signal processing of a time domain.

[0016]

[Embodiment of the Invention] Hereafter, a drawing explains the example of a gestalt of operation of this invention. Drawing 1 is the block diagram showing the configuration of the 1st of the control device of the array antenna of the example of a gestalt of operation of this invention. The equipment of this drawing is a control unit for controlling the array antenna 10 which consists of two or more antenna elements 10-1 - 10-n (n is a forward integer), and this. In addition, although it is applicable also to a two-dimensional array antenna, suppose the control unit of the array antenna by this invention that the case where it applies to a 1-dimensional array antenna (regular-intervals linearity array antenna) is shown in order to simplify explanation in the example of an operation gestalt shown below. The analog / a digital signal conversion means by which 11 changes the analog output from an antenna element 10-1 - 10-n into a digital signal in this drawing (An A/D-conversion means is called hereafter), a signal orthogonalization means for 12 to divide the output of the A/D-conversion means 11 into an I/Q rectangular cross channel, and to generate each rectangular signal, A space FFT count means by which 13 generates rectangular cross multi-beam power from each output of the signal orthogonalization means 12, A m-th FFT count means by which 14-1 - 14-n carry out the m piece (m is forward integer) rate of each output of the space FFT count means 13, respectively, The weighting-factor multiplication means which carries out the multiplication of the weighting factor calculated by weighting-factor count means 18 to mention 15-1-1 - 15-m-n later to an output the whole subband obtained from each of the m-th FFT count means 14-1 - 14-n, An addition means by which 16-1 - 16-m add the subband of the same frequency band among each beam power, It is a weighting-factor count means for a reverse FFT count means to restore 17 to the signal of m time domains using m inputs obtained simultaneously, and 18 to make an input child the feedback signal 19 mentioned later or 20, or to compute a weighting factor accommodative.

[0017] Next, actuation of the control unit of the array antenna in the example of a gestalt of operation of the 1st of this invention is explained based on drawing 1 . The signal received by each antenna element 10-1 - 10-n is changed into a digital signal with a predetermined sampling frequency by the A/D-conversion means 11, and after being separated into an I/Q rectangular cross channel by the signal orthogonalization means 12, it forms a multi-beam with the space FFT count means 13. The output of each formed beam is divided into m frequency bands by the m-th FFT count means 14-1 - 14-n on a cycle figure shaft, respectively. Here, the divided frequency band is called a subband. Since [of n beam power] it is divided into the subband of m individual, respectively, the subband output of nm individual will be obtained as a result.

[0018] And after the multiplication of the obtained subband is carried out by the weighting-factor multiplication means 15-1-1 - 15-m-n in a weighting factor, respectively, it adds the subband of the same frequency band by each beam power by the addition means 16-1 - 16-m. The obtained output of m pieces is inputted into the reverse FFT count means 17, and restores the signal of m time domains using m inputs obtained simultaneously.

[0019] On the other hand, the weighting-factor count means 18 computes a weighting factor with a predetermined algorithm by considering a feedback signal 19 or either of 20 as an input, and supplies it to the above-mentioned weighting-factor multiplication means 15-1-1 - 15-m-n. A feedback signal 19 is a signal which incorporated the above-mentioned addition means 16-1 - 16-m, and a feedback signal 20 is the output of the reverse FFT count means 17.

[0020] Drawing 2 is the block diagram showing the configuration of the 2nd of the control device of the array antenna of the example of a gestalt of operation of this invention. In this drawing, the same requirements for a configuration as the control unit of the array antenna of drawing 1 give the same reference mark. As different requirements for a configuration, 21-1 - 21-m are

beam selection means to be established for every subband of the same frequency band between each beam from the m-th FFT count means 14-1 - 14-n, and to compare the property for n inputted subbands in accordance with predetermined criteria, and to choose the beam power of p (p is forward integer and p<=n) individual from a good thing.

[0021] Next, actuation of the control unit of the array antenna in the example of a gestalt of operation of the 2nd of this invention is explained based on drawing 2 . The signal received by the antenna element 10-1 - 10-n is changed into a digital signal with a predetermined sampling frequency by the A/D-conversion means 11, and after being separated into an I/Q rectangular cross channel by the signal orthogonalization means 12, it forms a multi-beam with the space FFT count means 13. The output of each formed beam is divided into m bands by the m-th FFT count means 14-1 - 14-n on a cycle figure shaft, respectively. Here, the divided band is called a subband.

[0022] Next, the obtained subband output is inputted into the beam selection means 21-1 - 21-m for every subband of the same band between each beam. Here, in accordance with predetermined criteria, the property is compared for n inputted subbands, and p beam power is chosen and outputted from a good thing. Since [of p selected beam power] it is divided into the subband of m individual, respectively, the subband output of pm individual will be obtained as a result.

[0023] And after the multiplication of the obtained subband is carried out in a weighting factor from the weighting-factor multiplication means 15-1-1 - 15-m-p, respectively, it adds the subband of the same frequency band by each beam power by the addition means 16-1 - 16-m. The obtained output of m pieces is inputted into the reverse FFT count means 17, and restores the signal of m time domains using m inputs obtained simultaneously. In addition, about the weighting-factor count means 18, it is the same with having mentioned above in the example of a gestalt of the 1st operation.

[0024] Drawing 3 is the block diagram showing the configuration of the 3rd of the control device of the array antenna of the example of a gestalt of operation of this invention. In this drawing, the same requirements for a configuration as the control unit of the array antenna of drawing 1 give the same reference mark. As different requirements for a configuration, by carrying out over sampling technique in A/D conversion in the m-th FFT count means 14-1 - 14-n, the thing obtained and the subband whose signal component is lost by the band limit after reception are points which are not supplied to the latter part, and 0 [band] is written all over drawing.

[0025] Next, actuation of the control unit of the array antenna in the example of a gestalt of operation of the 3rd of this invention is explained based on drawing 3 . The signal received by the antenna element 10-1 - 10-n is changed into a digital signal with a predetermined sampling frequency by the A/D-conversion means 11. Next, after being separated into an I/Q rectangular cross channel by the signal orthogonalization means 12, a multi-beam is formed with the space FFT count means 13. The output of each formed beam is divided into m bands by the m-th FFT count means 14-1 - 14-n on a cycle figure shaft, respectively. Here, the divided band is called a subband. Since [of n beam power] it is divided into the subband of m individual, respectively, the subband output of nm individual will be obtained as a result.

[0026] And what is obtained, i.e., the subband whose signal component is lost by the band limit after a ****** thing and reception by having sampled on the frequency higher than a Nyquist rate, is not supplied to the latter part by carrying out over sampling technique in A/D conversion among the obtained subbands. In this way, after the multiplication of the subband with which the obtained signal component exists is carried out by the weighting-factor multiplication means 15-1-1 - 15-m-n in a weighting factor, respectively, it adds the subband of the same band by each beam power by the addition means 16-1 - 16-m. The obtained output of m pieces is inputted into the reverse FFT count means 17, and restores the signal of m time domains using m inputs obtained simultaneously. In addition, about the weighting-factor count means 18, it is the same with having mentioned above in the example of a gestalt of the 1st operation.

[0027] In addition, the configuration of the example of a gestalt of each operation mentioned above is a mere example, and can also be configuration the combination of the example of a gestalt of each operation, and it can also constitute the combination in arbitration. moreover, the

thing to which the example of a gestalt of the operation described above is shown, and limits an example of this invention -- it is not -- this invention -- others -- deformation -- a mode -- and -- modification -- it can carry out in a mode. Therefore, the range of this invention is specified by only a claim and its equal range.

[0028]

[Effect of the Invention] As explained to the detail above, according to this invention, by adopting a beam space method and constituting a full reconstruction filter, distortion of the local depression in the spectrum of all bands etc. can be avoided, a good beam can be chosen more finely, and S/(N+I) of an output signal can be improved as a result. Moreover, the output of the subband which does not contain the information signal component only for over sampling technique can reduce computational complexity, without dropping delay signal incorporation capacity by supposing that it does not adopt.

[Translation done.]

TECHNICAL FIELD

[Field of the Invention] This invention relates to the control approach of an array antenna and equipment which are used for various radiocommunication.

[Translation done.]

* NOTICES *

JPO and INPIT are not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

PRIOR ART

[Description of the Prior Art] An ecad array antenna gives directivity strong against a certain direction by multiplying and compounding a suitable weighting factor to the signal received by each antenna element, or makes it possible not to receive as 0 and to carry out sensibility only to the signal which comes from the direction in reverse. By supplying a suitable weighting factor according to change of an electric-wave environment, such an antenna performs the optimal beam shape **, realizes spatial filtering, and it is used in order to avoid interference with other radio communications systems.
[0003] In recent years, application to the mobile communications of the array antenna using digital signal processing attracts attention with development of a digital-signal-processing technique and the miniaturization of equipment. When application to mobile communication system is taken into consideration, the response to a multi-pass phasing environment poses a problem. While canceling spatially an interference signal [**** / signal / of choice /-less], the delay signal of the signal of choice should be incorporated, should carry out in-phase synthesis to the signal of choice, and should make S/(N+I) of an output signal contribute to an improvement ideally. It is known for reference that the in-phase synthesis of a delay signal has effective configuration which performs signal processing on the time-axis which used the delay element (TDL;Tapped Delay Line) and configuration which performs signal processing on the frequency shaft using a full reconstruction filter. In such reference, they are R.T.Compton, Jr., "The Rela-tionship Between Tapped Delay-Line and FFT Processing in Adaptive Arrays", IEEE Transactions on Antennas and Propagation, vol.36, No.1, and January1988. It is.
[0004] If here shows the conventional array antenna control unit by this reference to drawing 4 , the output of each antenna element 41-1 - 41-Q (Q is a forward integer) will be sampled by A/D converter 42-2 - 42-Q with a predetermined sampling frequency, respectively. For every antenna element, K samplings obtained by A/D converter 42-2 - 42-Q are once stored in an input buffer 43-2 - 43-Q, and are carried out to conversion using FFT 44-2 - 44-Q, and, as for K frequency-domain samples of the changed antenna element, the multiplication of the weighting factor is carried out respectively. The sample to which the multiplication of the weighting factor in every frequency domain of each antenna element was carried out is totaled, is supplied to IFFT45, and is reconfigurated by the signal of a time domain. Thus, there is no difference essential to the engine performance of two effective configurations mentioned above. However, with the configuration which performs frequency band division signal processing, since signal processing like the multiplication of a weighting factor to the divided band can be performed to juxtaposition and the updating period of a weighting factor can be lengthened, the count load to a computer can be mitigated in instrumentation, and it becomes advantageous.
[0005] In the conventional array antenna which performs frequency band division signal processing, an input signal is divided on a frequency shaft, the combination of the filter which reconfigurates this divided signal is needed, and such a filter is called the full reconstruction filter. The combination of FFT/IFFT is one of the full reconstruction filters. In case digital signal processing is performed, it is effective to adopt the full reconstruction filter by the combination of FFT/IFFT also from the problem of a count load.
[0006] On the other hand, if instrumentation is taken into consideration, relief of the count load

to the computer to a weighting-factor computational algorithm will pose an important problem. As the relief technique of the count load for obtaining a weighting factor, conventionally, a fixed multi-beam is beforehand constituted from the preceding paragraph of a weighting-factor computational algorithm, and there is a beam space method which carries out signal processing to each beam power. In performing signal processing for beam shape ** of an array antenna, this beam space method is the technique of forming a beforehand fixed multi-beam as pretreatment not using a component output, and performing signal processing to the output of a beam directly. As for such a fixed multi-beam, it is common to be formed of Space FFT in the Butler matrix and a digital field in an analog field. Since space division is performed by applying a beam space method and using the output of the formed fixed beam, it will concentrate on a specific beam and the signal power of choice has the merit from which the input signal which has improved the S/N ratio is obtained.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] As explained to the detail above, according to this invention, by adopting a beam space method and constituting a full reconstruction filter, distortion of the local depression in the spectrum of all bands etc. can be avoided, a good beam can be chosen more finely, and S/(N+I) of an output signal can be improved as a result. Moreover, the output of the subband which does not contain the information signal component only for over sampling technique can reduce computational complexity, without dropping delay signal incorporation capacity by supposing that it does not adopt.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] Although it is a band assembled-die array antenna with such a merit, when application to mobile communication system is considered, many delay signals of the signal of choice produced according to the multi-pass phasing environment exist as a description of the environment, and it is raised that the number is usually over the degree of freedom of an array antenna. Such an environment makes it easy to lapse into the local solution instead of an optimum solution, as an antenna searches for the weighting factor which can perform the optimal reception by a certain approach. The engine performance of an array antenna is made to deteriorate as a result.
[0008] Moreover, when actual instrumentation is taken into consideration, since the number of the weighting factors which signal processing takes increases in proportion to the degree of FFT which performs the element number of an array, and band division, the degree of a weighting-factor computational algorithm becomes large, and a frequency-division mold array antenna becomes huge [computational complexity]. It is known that the capacity which incorporates the delay signal of the signal of choice and carries out in-phase synthesis to the signal of choice serves as a direct, the degree of FFT, i.e., number of band division, parameter with the configuration which performs time-domain signal processing which used TDL in the configuration which performs frequency band division signal processing which uses the die length of TDL, and FFT/IFFT, and the amount of delay in which both sides are in confusion, so that it is long will become large. However, this is RLS (Recursive Least Squa-re) to which the number of both methods of the weighting factors which should be calculated, so that the capacity to incorporate a delay signal is investigated will increase, and computational complexity increases to the cube of an input signal. Effect is large when adopting an algorithm like law as a weighting-factor computational algorithm.
[0009] On the other hand, if the signal power of choice can be centralized on a specific beam by application of the above-mentioned beam space method, the beam power which does not almost have the signal power of choice in reverse will also be obtained. Then, after forming a fixed multi-beam from the former, predetermined criteria compare each of that output and there is the technique of choosing only a good thing and reducing the number of beams. However, with such a configuration, since it is aimed at the perimeter wave number band in comparing power and S/N, a beam will be chosen, with the distortion of the spectrum on the frequency shaft it is supposed that is easy to be generated especially in broadband communication in a multi-pass phasing environment included. For this reason, since this distortion will remain as it is when some spectrums of all bands are low selectively, in a time domain, distortion remains in a wave.
[0010] By this invention's being for solving these troubles, and adopting a beam space method, and constituting a full reconstruction filter While being able to avoid distortion of the local depression in the spectrum of all bands etc., being able to choose a good beam more finely and being able to improve S/(N+I) of an output signal The output of the subband which does not contain the information signal component only for over sampling technique aims at offering the control approach of an array antenna and equipment which can reduce computational complexity, without dropping delay signal incorporation capacity by supposing that it does not adopt.

[Translation done.]

MEANS

[Means for Solving the Problem] In order to solve the above troubles, this invention applies a beam space method to a band assembled-die array antenna. As mentioned above, in performing signal processing for beam shape ** of an array antenna, directly, a beam space method forms a beforehand fixed multi-beam as pretreatment not using a component output, is the technique of performing signal processing to the output of a beam, and has the merit from which the input signal which has improved the S/N ratio is obtained. For this reason, when a certain weighting-factor computational algorithm searches for the weighting factor which performs the optimal reception, it falls and wears in a local solution and there is nothing with Lycium chinense, and it becomes easy to search for the combination of a near weighting factor the more nearly optimal.
[0012] On the other hand, as for the index which chooses the beam choice method in the configuration of the conventional beam space method as technique for computational complexity relief, the spectrum of all the bands of the input signal concerned had been [the object of that and selection] applicable why. For this reason, it will be influenced [distorted] of the spectrum produced in a frequency selective phasing environment.
[0013] In the control approach of the array antenna which controls the weighting factor of the ecad array antenna which forms a radiation beam accommodative as a means for solving this trouble according to change of an electric-wave environment accommodative, the multiplication of the weighting factor which divided the input signal on the frequency shaft and was controlled by the signal of each divided frequency band accommodative is carried out, and each result which carried out multiplication is reconfigurated to the signal on a time-axis. Moreover, in the control approach of an array antenna of performing digital signal processing, space FFT is given to the input signal of each component antenna, a fixed rectangular cross multi-beam is generated, the multiplication of the weighting factor which divided each rectangular cross multi-beam power of all concerned into the frequency domain, and was controlled by the signal of each divided frequency band accommodative is carried out, this multiplication result is totaled for every frequency band, each total output for every frequency band is processed, and it restores to the signal of a time domain. Therefore, according to this invention, distortion of the local depression in the spectrum of all bands etc. is avoided, and a good beam can be chosen more finely.
[0014] Moreover, FFT of a time domain is given to each rectangular cross multi-beam power of all, it divides into a frequency domain, reverse FFT processing of each output which totaled the multiplication result of having carried out the multiplication of the weighting factor, for every frequency band is carried out, and it restores to the signal of a time domain. Furthermore, it compares for every frequency band which divided two or more beam power, and only a predetermined number of beams are chosen in the light of predetermined criteria. For this reason, distortion of the local depression in the spectrum of all bands etc. is avoided, and a good beam can be chosen more finely. As a result, S/(N+I) of an output signal is improvable.
[0015] Furthermore, when an input signal receives an analog / digital signal conversion in performing digital signal processing, as for the sampling frequency in that case, it is common to be set up more highly than a Nyquist rate. If this condition is seen on a frequency shaft, the subband which does not contain the information signal component only for over sampling

technique will be generated. In the subband which originally does not include an information signal, most of the components are noises, and it does not have to give and carry out the multiplication of the weighting factor. However, it will contribute to incorporation of a delay signal. Therefore, each rectangular cross multi-beam power of all is divided into a subband in a frequency domain. The subband output which does not contain the signal component of choice since the subband output and the signal wishing reception which are acquired by having sampled on the frequency higher than a Nyquist rate among the divided subband outputs have received the band limit is not supplied to the latter part as 0. The multiplication of the weighting factor which supplied only the subband which hits the passband of the signal of choice, and was controlled accommodative by the signal for every supplied subband is carried out. As a result, the output of the subband produced by over sampling technique is supposing that it does not adopt, and it can reduce computational complexity, without dropping delay signal incorporation capacity. In addition, the approach of such a computational complexity cutback is impossible with the configuration using TDL which performs signal processing of a time domain.

[0016]

[Embodiment of the Invention] Hereafter, a drawing explains the example of a gestalt of operation of this invention. Drawing 1 is the block diagram showing the configuration of the 1st of the control device of the array antenna of the example of a gestalt of operation of this invention. The equipment of this drawing is a control unit for controlling the array antenna 10 which consists of two or more antenna elements 10-1 - 10-n (n is a forward integer), and this. In addition, although it is applicable also to a two-dimensional array antenna, suppose the control unit of the array antenna by this invention that the case where it applies to a 1-dimensional array antenna (regular-intervals linearity array antenna) is shown in order to simplify explanation in the example of an operation gestalt shown below. The analog / a digital signal conversion means by which 11 changes the analog output from an antenna element 10-1 - 10-n into a digital signal in this drawing (An A/D-conversion means is called hereafter), a signal orthogonalization means for 12 to divide the output of the A/D-conversion means 11 into an I/Q rectangular cross channel, and to generate each rectangular signal, A space FFT count means by which 13 generates rectangular cross multi-beam power from each output of the signal orthogonalization means 12, A m-th FFT count means by which 14-1 - 14-n carry out the m piece (m is forward integer) rate of each output of the space FFT count means 13, respectively, The weighting-factor multiplication means which carries out the multiplication of the weighting factor calculated by weighting-factor count means 18 to mention 15-1-1 - 15-m-n later to an output the whole subband obtained from each of the m-th FFT count means 14-1 - 14-n, An addition means by which 16-1 - 16-m add the subband of the same frequency band among each beam power, It is a weighting-factor count means for a reverse FFT count means to restore 17 to the signal of m time domains using m inputs obtained simultaneously, and 18 to make an input child the feedback signal 19 mentioned later or 20, or to compute a weighting factor accommodative.

[0017] Next, actuation of the control unit of the array antenna in the example of a gestalt of operation of the 1st of this invention is explained based on drawing 1 . The signal received by each antenna element 10-1 - 10-n is changed into a digital signal with a predetermined sampling frequency by the A/D-conversion means 11, and after being separated into an I/Q rectangular cross channel by the signal orthogonalization means 12, it forms a multi-beam with the space FFT count means 13. The output of each formed beam is divided into m frequency bands by the m-th FFT count means 14-1 - 14-n on a cycle figure shaft, respectively. Here, the divided frequency band is called a subband. Since [of n beam power] it is divided into the subband of m individual, respectively, the subband output of nm individual will be obtained as a result.

[0018] And after the multiplication of the obtained subband is carried out by the weighting-factor multiplication means 15-1-1 - 15-m-n in a weighting factor, respectively, it adds the subband of the same frequency band by each beam power by the addition means 16-1 - 16-m. The obtained output of m pieces is inputted into the reverse FFT count means 17, and restores the signal of m time domains using m inputs obtained simultaneously.

[0019] On the other hand, the weighting-factor count means 18 computes a weighting factor

with a predetermined algorithm by considering a feedback signal 19 or either of 20 as an input, and supplies it to the above-mentioned weighting-factor multiplication means 15-1-1 - 15-m-n. A feedback signal 19 is a signal which incorporated the above-mentioned addition means 16-1 - 16-m, and a feedback signal 20 is the output of the reverse FFT count means 17.
[0020] Drawing 2 is the block diagram showing the configuration of the 2nd of the control device of the array antenna of the example of a gestalt of operation of this invention. In this drawing, the same requirements for a configuration as the control unit of the array antenna of drawing 1 give the same reference mark. As different requirements for a configuration, 21-1 - 21-m are beam selection means to be established for every subband of the same frequency band between each beam from the m-th FFT count means 14-1 - 14-n, and to compare the property for n inputted subbands in accordance with predetermined criteria, and to choose the beam power of p (p is forward integer and p<=n) individual from a good thing.
[0021] Next, actuation of the control unit of the array antenna in the example of a gestalt of operation of the 2nd of this invention is explained based on drawing 2 . The signal received by the antenna element 10-1 - 10-n is changed into a digital signal with a predetermined sampling frequency by the A/D-conversion means 11, and after being separated into an I/Q rectangular cross channel by the signal orthogonalization means 12, it forms a multi-beam with the space FFT count means 13. The output of each formed beam is divided into m bands by the m-th FFT count means 14-1 - 14-n on a cycle figure shaft, respectively. Here, the divided band is called a subband.
[0022] Next, the obtained subband output is inputted into the beam selection means 21-1 - 21-m for every subband of the same band between each beam. Here, in accordance with predetermined criteria, the property is compared for n inputted subbands, and p beam power is chosen and outputted from a good thing. Since [of p selected beam power] it is divided into the subband of m individual, respectively, the subband output of pm individual will be obtained as a result.
[0023] And after the multiplication of the obtained subband is carried out in a weighting factor from the weighting-factor multiplication means 15-1-1 - 15-m-p, respectively, it adds the subband of the same frequency band by each beam power by the addition means 16-1 - 16-m. The obtained output of m pieces is inputted into the reverse FFT count means 17, and restores the signal of m time domains using m inputs obtained simultaneously. In addition, about the weighting-factor count means 18, it is the same with having mentioned above in the example of a gestalt of the 1st operation.
[0024] Drawing 3 is the block diagram showing the configuration of the 3rd of the control device of the array antenna of the example of a gestalt of operation of this invention. In this drawing, the same requirements for a configuration as the control unit of the array antenna of drawing 1 give the same reference mark. As different requirements for a configuration, by carrying out over sampling technique in A/D conversion in the m-th FFT count means 14-1 - 14-n, the thing obtained and the subband whose signal component is lost by the band limit after reception are points which are not supplied to the latter part, and 0 [band] is written all over drawing.
[0025] Next, actuation of the control unit of the array antenna in the example of a gestalt of operation of the 3rd of this invention is explained based on drawing 3 . The signal received by the antenna element 10-1 - 10-n is changed into a digital signal with a predetermined sampling frequency by the A/D-conversion means 11. Next, after being separated into an I/Q rectangular cross channel by the signal orthogonalization means 12, a multi-beam is formed with the space FFT count means 13. The output of each formed beam is divided into m bands by the m-th FFT count means 14-1 - 14-n on a cycle figure shaft, respectively. Here, the divided band is called a subband. Since [of n beam power] it is divided into the subband of m individual, respectively, the subband output of nm individual will be obtained as a result.
[0026] And what is obtained, i.e., the subband whose signal component is lost by the band limit after a ****** thing and reception by having sampled on the frequency higher than a Nyquist rate, is not supplied to the latter part by carrying out over sampling technique in A/D conversion among the obtained subbands. In this way, after the multiplication of the subband with which the obtained signal component exists is carried out by the weighting-factor multiplication means 15-

1-1 - 15-m-n in a weighting factor, respectively, it adds the subband of the same band by each beam power by the addition means 16-1 - 16-m. The obtained output of m pieces is inputted into the reverse FFT count means 17, and restores the signal of m time domains using m inputs obtained simultaneously. In addition, about the weighting-factor count means 18, it is the same with having mentioned above in the example of a gestalt of the 1st operation.
[0027] In addition, the configuration of the example of a gestalt of each operation mentioned above is a mere example, and can also be configuration the combination of the example of a gestalt of each operation, and it can also constitute the combination in arbitration. moreover, the thing to which the example of a gestalt of the operation described above is shown, and limits an example of this invention -- it is not -- this invention -- others -- deformation -- a mode -- and -- modification -- it can carry out in a mode. Therefore, the range of this invention is specified by only a claim and its equal range.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the block diagram showing the configuration of the 1st of the control device of the array antenna of the example of a gestalt of operation of this invention.
[Drawing 2] It is the block diagram showing the configuration of the 2nd of the control device of the array antenna of the example of a gestalt of operation of this invention.
[Drawing 3] It is the block diagram showing the configuration of the 3rd of the control device of the array antenna of the example of a gestalt of operation of this invention.
[Drawing 4] It is the block diagram showing the configuration of the conventional array antenna control device.
[Description of Notations]
10 Array Antenna
10-1 - 10-n Antenna element
11 Analog / Digital Conversion Means
12 Signal Orthogonalization Means
13 Space FFT Count Means
14-1 - 14-n m-th FFT count means
15-1-1 - 15-m-n Weighting-factor multiplication means
16-1 - 16-m Addition means
17 Reverse FFT Count Means
18 Weighting-Factor Count Means
21-1 - 21-m Beam selection means

[Translation done.]